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INTELLECTUAL PROPERTY RIGHTS, GLOBALIZATION AND GROWTH

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Intellectual Property Rights, Globalization and Growth*

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Abstract

I present a model that combines the key features of a Schumpeterian growth model without scale effects and a North – South model of trade. All open economies converge to parallel growth paths because of costly technological transfer. I study the effects of intellectual property rights (IPR) regimes and trade policies on the growth rate, as well as on a given country's economic performance. The requirement that trade be balanced neutralizes all potential effects of the tariff policy on the world's growth rate, and on the performance of a single country. By contrast, an improvement of a given country's IPR regime is growth neutral but improves a country's position in the world's productivity rank. These findings are shown to be consistent with observedempirical relationships.

JEL classification: F1, O3, O4.

Keywords: Intellectual Property Rights, Economic growth, International Trade.

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1 Introduction

One of the main concerns of the modern theory of economic development is how globalization affects economic performance. A significant recent aspect of globalization is the tremendous rise in the degree of economic openness and integration across the world. A key feature of this phenomenon is the increasing developing country share of world trade. Currently trade between the developed (OECD) and developing (non-OECD) countries is the fastest growing category in trade growth statistics. For example, over the past thirty years, the volume of U.S. trade (as a share of US GDP) with non-OECD economies has increased more than four-fold.

The issue of trade openness and the reduction of trade barriers is currently a matter of international debate. Until the mid nineties the developed countries had been the most active pursuers of trade liberalization, whereas now many amongst the less developed countries have begun to promote tariff reduction. The most important example is the case of China where the chance to join the WTO is being touted by their leaders as a way "to grow rich".

The perception of beneficial effects of trade on growth seems to stand at odds with empirical findings, however. The tremendous growth in trade volumes contrasts with fairly stable growth rates that have been observed over the past 100 years in developed economies. A natural question to ask is whether the rising degree of trade openness has indeed had any effect on the growth rate of advanced countries, and whether we should expect it to. The present paper analyzes the effects of changing trade policies on regional economic performance as well as on the world's growth rate. A related issue addressed is the effect that the degree of protection of intellectual property rights (IPR) in developing countries has on this. Many experts and commentators have argued that improvement in poor countries' intellectual property rights is key to obtaining growth enhancing effects. The importance of the issue of IPR was confirmed by its inclusion into the statutes of the WTO in 1994. However, after more than ten years, the extent to which less developed countries should protect intellectual property, and in whose interests such protection should be implemented, is still not clear.

From a theoretical point of view there is no doubt that intellectual property rights matter. Most economists agree that technology is the engine of growth, and the key element that motivates people to devote resources to beneficial technology improvements is the potential to exploit rents from it that the protection of intellectual property allows. Most authors agree that high standards of IPR protection are beneficial for the innovating economies (Dinopoulos and Segerstrom 2005; Gancia, 2003; Connolly and Valderrama, 2005). Some studies (e.g. Helpman, 1993) have, however, highlighted the negative aspects of IPR protection for lagging economies. Strong enforcement of intellectual property protection increases consumer prices and reduces trade benefits that could be crucial for developing economies. Most of these studies implicitly assumed perfect substitutability between internationally produced goods. Here I refer to famous hypothesis formulated by Armington (1969) and summarized by Krugman and Obstfeld (1994), that goods are differentiated according to region of origin. In other words, even within the same sector internationally produced goods are perceived by consumers as imperfect substitutes. Such formulation drifts the attention away from the international aspect of intellectual property rights and points at the local issues of IPR protection.

The term globalization mostly refers to an increase in international openness. In this study I analyze two different cases of openness: openness to international flows of ideas and openness to trade. In addition to the effects of trade policies, I consider the impact of regional intellectual property rights regimes on regional economic performance and the world's growth rate. Both issues previously highlighted in the literature play a role: IPR affects the incentives for research in the developed countries as well as prices paid by consumers. The present study seeks to understand to what extent improvements in local IPRs have an effect on the long run growth rate in a globalized world. It also analyzes the nature of transitional changes and the role that trade tariffs play in the interaction with these changes. Finally, the framework is useful for addressing the issue of whether partial openness (i.e. for trade only, and not for ideas), or no openness, could be more beneficial for a lagging country than full participation in globalized markets.

I develop a dynamic, general equilibrium model of growth and trade that, importantly, has no scale effects to analyze these issues. To do this, I merge two streams of the literature - modern endogenous growth theory (which allows sophisticated representation of an economy without scale effects) and North - South trade models (with the well-modelled international interactions). I use an extension of the Armington hypothesis to implement trade equations. Using a model without scale effects is essential here because the size of markets increases many fold when countries open themselves to international trade. Models with scale effects, though simpler, lead to immediately counter-factual implications regarding growth rates, and are therefore of little use in analyzing growth related issues. The model developed here is a Schumpeterian multi-region model of growth with both horizontal and vertical expansions. One region (denoted the frontier country) is determined endogenously as the technological leader and has highest aggregate productivity. Firms from the frontier country devote resources to innovative R&D to discover higher quality products and firms from all other countries devote resources to imitative R&D to copy the discoveries made by the technological leaders. A successful imitation results in quality upgrading of local products, that differ to some extent from their models in the frontier country. The costs of imitation in a given country depend on its distance to the technological frontier of the frontier country. The rates of innovation and imitation are endogenously determined based on expected profit maximization together with labor market clearing conditions. Balanced trade accounts determine the degree of wage inequality between the frontier country and given lagging country.

The paper relates closely to various streams of the literature. The first is the modern Schumpeterian growth literature pioneered by Grossman and Helpman (1991a), Aghion and Howitt (1991), Segerstrom, Anant and Dinopoulos

(1990), and developed further by Young (1998), Howitt (1999) and Peretto and Smulders (2002). This stream of literature is concerned with the mechanics of economic growth. The recent contributions allow modelling economies growing at constant rates with factor inputs growing (hence - these models are consistent with empirical observations). The scale effect is neutralized in these models by markets expanding into new sectors which effectively dilutes research efforts pushing the frontier. The more populous a given economy, the greater the number of sectors (and thus potential directions of research) it comprises.

Although elegant and consistent with the data, such formulations cause problems when it comes to modelling trade. The question of what happens when two countries of different sizes (i.e. with a different number of sectors) start to trade still remains unaddressed in the studies that build on models without scale effects. Until now the literature that employed growth models without scale - effects focused on the flow of ideas as the only means by which international interaction occurred. Here, I posit a modelling solution to the problem of trade between countries of different sizes and hence am able to analyze this situation as well. The key assumption which allows this is that the trade of goods from various sectors facilitates horizontal expansion in smaller countries. This allows me to solve the model without introducing scale effects while at the same time not violating balanced trade accounting.

The paper is also closely related to the literature on North - South trade.[1] I build on the existing North - South trade models (Grossman and Helpman 1991b, Taylor 1993 and 1994) with the addition of components that allow me to generate a model without scale effects. Some existing studies in this literature have solved the problem of scale effects by postulating the heterogeneity of countries with respect to R&D capabilities (Dinopoulos and Segerstrom, 2005). In contrast, I present a general framework in which there are no innate differences across agents in their capacity to perform R&D.

An additional question often analyzed in the growth literature concerns so called conditional convergence, see Barro and Sala-i-Martin (1997).[2] Conditional convergence seems to be confirmed by empirical studies (see Barro, 2001 for an overview) and assigns to each economy its destination position in the world's productivity rank. Changes in policy might result in a shift in such destination positions and lead to transitional growth. Numerous studies highlight factors that could affect conditional convergence, such as capital productivity, rules of law, or distortions of domestic and international markets. My study contributes by adding the degree of intellectual property rights protection and relative size of a given economy (in terms of R&D capable population) as additional factors that could affect conditional convergence. The quality of intellectual property rights is often assumed to be captured by the R&D productivity parameter, which does not allow for a deeper analysis of potential disadvantages of strong IPR (Barro and Sala-i-Martin, 1997; Dinopoulos and Segerstrom, 2005). Other existing studies that analyze aspects of intellectual

[1] See Krugman and Obstfeld (1994) for an excellent reference.

[2] *Conditional convergence* is a particular case of so-called β-convergence (Barro and Sala-i-Martin, 1995).

property protection mainly discuss their international aspects (Taylor 1993 and 1994, Gancia, 2003). A number of studies (e.g. Helpman 1993, Grossman and Lai, 2004) that consider local IPR regimes, focus on the potential drawbacks of strong IPR. Recent evidence on the costliness of imitation (Coe and Helpman, 1995 or Benhabib and Spiegel, 2002) suggests that one should include the costs of imitative R&D also. This could significantly change the conclusions by neutralizing the negative price effect through increased R&D incentives. My study also develops this direction. Here, stronger IPR increases the price of locally produced goods, and also increases the expected returns from investment (which matters with positive costs of imitation).

The main results of the paper are: (1) an improvement in IPR by lagging countries does not have any global effect on growth rates. If any group of lagging countries (no matter how large) decides to change its IPR regime, this will only affect countries within this group. (2) Any improvement of intellectual property protection implies a change in the distribution of individual incomes. Particularly, the share of income accruing to monopolistic firms grows and the share that comes from wages paid to labor shrinks. (3) The factors that determine conditional convergence are the degree of IPR protection and the volume of skilled (R&D capable) workers in the economy. (4) No openness (autarky) of a single lagging country may result in faster growth than engagement in globalization (full openness).

This paper is structured as follows. The next section sketches the theoretical model. Section three presents the dynamics of the model. Section four presents the main properties of the equilibrium and discusses the potential benefits of openness. Section five performs a simple empirical test that supports the theoretical predictions. The last section concludes and points out directions for future research.

2 The Model

In this section I discuss the role of the main assumptions that underlie the theoretical model. I also present the basic equations I will use in my analysis. The construction of the model presented in this section heavily follows so called Schumpeterian models of creative destruction proposed by Grossman and Helpman (1991a) and Aghion and Howitt (1992) though the formulation here, which aims to rule out scale effects is heavily influenced by Howitt (1999 and 2000).

2.1 Overview

Consider a multi - region model where regions are distinguished by the size of population and by the degree of intellectual property rights (IPR) protection. Specifically, there is only one region - the frontier country - where intellectual property is fully protected.[3] All other regions - the lagging countries - have

[3] Generally, the frontier country offers the highest level of IPR protection in the world. I assume that intellectual property is perfectly protected in the frontier country just for com-

weaker and thus imperfect protection of intellectual property.

Each region has a continuum of sectors that produce commodity goods. Each sector is subject to technical progress. Workers in all regions are assumed to be capable of conducting vertical (technology improving) R&D that reduces the costs of production. Each industry offers an infinite number of potential technology improvements. Meanwhile there are new sectors created in the process of serendipitous discoveries. Newly created sectors start with technological levels similar to those already existing.

There are two channels of international interaction: trade in commodities and the flow of ideas. Incentives for trade come from individual preferences as individuals gain additional utility from consumption of international products. This is an extension of the Armington hypothesis, and in practice this is expressed by a standard CES-utility function with goods differentiated with respect to their origin of production.

The second channel of international interaction is flow of ideas. It affects both: vertical and horizontal expansion. First, international flow of ideas allows for imitation of old technologies in the lagging countries. Imitation requires some resources to be spent. The costliness of imitation is an observed and widely accepted phenomenon, see for example Mansfield, Schwartz and Wagner (1981), Coe and Helpman (1995) or Benhabib and Spiegel (2002). Costliness implies that when a country wants to create a new generation of a product, or to open a new line of varieties, it must pay costs proportional to the costs that have been paid to make the discovery and proportional to the current stat-of-the-art technology in the given sector. This is captured by an *index of copying difficulty*. This index depends positively on the size of the lag relative to the advanced country. In terms of vertical R&D - the further a sector in a given country is from the technological frontier, and the more steps "up-the quality ladder" have been made abroad, the easier it is to take the next step. The second case of international flow of ideas concerns the pace of horizontal expansion (opening of new sectors). The new sectors are being created in the process of serendipitous discoveries. However, the open countries can benefit from trade with goods of new sectors, so that countries that trade with goods have same numbers of sectors opened.

2.2 Industry structure

There is a continuum of regions indexed by j, that range from 0 to 1. In each region there is a continuum of industries indexed by $i \in [0, B_{jt})$, where B_{jt} measures the total number of different industries in the region. In each industry i firms differ with respect to the technology of production they posses. A better technology implies lower unit costs required to produce a given good i. To discover unit cost reductions, firms in each industry participate in innovative R&D races. When the state-of-the-art technology in a given industry is k, the next winner of an innovative R&D race becomes the sole producer with a $k+1$

putational convenience.

technology. Thus, over time, the quantities produced grow as innovations push technology in each industry up its “quality ladder”.

A more detailed representation of the industry structure is presented later.

2.3 Individuals

Each region has a fixed number of households. Each household member lives forever and is endowed with one unit of labor that is inelastically supplied in exchange for wage (w_{j^*t}). The number of members of each household grows exponentially at a fixed rate $g_L > 0$, the population growth rate. Each region has identical rates of population growth so that the ratios of population volumes in all regions are proportional. Let $\bar{L}_{j^*} > 0$ be the size of representative household in region j^* and let L_{j^*t} denote the supply of labor in region j^* at time t, hence:

$$L_{j^*t} = \bar{L}_{j^*} e^{g_L t} \tag{1}$$

Households in all countries share identical preferences. Each household is modeled as a dynastic family that consists of infinitely-lived consumers that maximizes discounted lifetime utility given by:

$$U = \int_0^\infty e^{g_L t} e^{-\rho t} \ln u(c_t) dt \tag{2}$$

where $u(c_t)$ denotes the individual utility form consumption at t and ρ is the rate of time preference. Optimal consumption growth $\dot{c}/c$ requires

$$r = \rho - g_L - \frac{\dot{c}}{c}. \tag{3}$$

Individual utility at t is equal to:

$$\ln u(c_t) = \int_0^{B_{jt}^{\max}} \ln u(c_t(i)) di \tag{4}$$

where $u_t(c_t(i))$ denotes the utility of consumption of products from sector i and $B_{j^*t}^{\max}$ denotes the total number of sectors, of which goods are available in j^*. Goods in each sector i can be produced in any region j. The individual utility of consumption of a product from sector i is therefore:

$$u(c_t(i)) = \left(\int_0^1 c_{jt}(i)^{(\alpha-1)/\alpha} dj \right)^{\alpha/(\alpha-1)}, \alpha > 1 \tag{5}$$

so that products from different regions are gross substitutes.

Denote the per sector expenditures in country j^* by E_{j^*t}. Each individual at time t maximizes $u(c_t(i))$ subject to the budget constraint. The logarithmic preferences defined by (4) imply that in equilibrium each individual spends equal amounts per sector. Within each sector he demands goods produced in all countries. Note that this also implies that consumers choose the cheapest products from each industry of each country. To express the gross prices that consumers need to pay for a given good, introduce the parameter $\tau_{j^*} \geq 1$. This parameter reflects the institutional, legal and regulatory impediments to entering directly into a market of country j^* by offering a consumption product. Parameter τ_{j^*} should be interpreted as an iceberg cost of international trade.[4] The case of $\tau_{j^*} = 1$ denotes fully free access to international markets; the opposite, limiting case of $\tau_{j^*} \to \infty$ represents extremely high levels of tariffs so that there is no international trade with a given country. The case when $\tau_{j^*} \to \infty$ will be discussed in subsection 4.1.

The total demand for good i produced in country j^* equals:

$$q_{j^*t}(i) = \int_0^1 E_{jt} \frac{\left(\tau_{jj'} p_{j^*t}(i)\right)^{-\alpha}}{\int_0^1 \left(\tau_j p_{kt}(i)\right)^{1-\alpha} dk} dj \tag{6}$$

where:

- $\tau_{jj'}$ are the tariffs imposed by j on j' such that: $\tau_{j^*j'} = 1$ if $j^* = j'$ and $\tau_{j^*j'} = \tau_{j^*}$ otherwise,
- $p_{j^*t}(i)$ is the price in industry i in country j^* at t.

2.4 Production

Production consists of continuum of industries (indexed by i) using labor as the only input. One worker at time t can produce $A_{j^*t}(i)$ goods in industry i in country j^*. $A_{j^*t}(i)$ changes as a result of technological progress. Every new discovery increases $A_{j^*t}(i)$ by an exogenous factor $\lambda > 1$.

Every new discovery results in the establishment of a local monopolist that has the unique right to produce with the state-of-the-art technology $A_{j^*t}(i)$ in j^*. We will assume that discoveries are large enough so that there is no potential threat of domestic competition.[5] Thus, a monopolist in a given sector is restricted only by international competition. Denote the instantaneous profits of a regional quality leader by $\Pi_{j^*t}(i)$, where:

$$\Pi_{j^*t}(i) = \left(p_{j^*t}(i) - w_{j^*t}/A_{j^*t}\right) q_{j^*t}(i) \tag{7}$$

Maximizing $\Pi_{j^*t}(i)$ with respect to $p_{j^*t}(i)$ and taking into account equation (6) determines the unconstrained monopolistic price:

$$p_{j^*t}(i) = \left(\frac{\alpha}{\alpha - 1}\right) \frac{w_{j^*t}}{A_{j^*t}} \tag{8}$$

[4] One can assume that the tariff revenues are paid back to citizens of j^* as a lump - sum transfer.

[5] Alternatively suppose that each time a new discovery occurs, the old monopolist faces a threat of being undercut by the new entrant that possesses now a better technology. Therefore the old monopolist decides to quit the market.

which is the standard monopoly markup of price over marginal cost. Equation (8) implies that a regional quality leader in given industry at time t earns the flow profit of:

$$\Pi_{j^*t}(i) = \left(\frac{1}{\alpha - 1}\right)\frac{w_{j^*t}}{A_{j^*t}}q_{j^*t}(i) \tag{9}$$

Recall that there is a continuum of markets, so that there is no effect of a single market on total demand. Hence instantaneous profits at t of a regional monopolist in j^* are equal to:

$$\Pi_{j^*t}(i) = \varepsilon\left(\alpha\right)\left(\frac{w_{j^*t}}{A_{j^*t}(i)}\right)^{1-\alpha} Q_t(i) \tag{10}$$

where:

$$Q_t(i) \equiv \int_0^1 \frac{E_{jt}/\tau_j^\alpha}{\int_0^1 \left(\tau_j p_{kt}(i)\right)^{1-\alpha} dk} dj \tag{11}$$

$$\varepsilon\left(\alpha\right) \equiv \frac{\left(\alpha - 1\right)^{\alpha - 1}}{\alpha^\alpha} \tag{12}$$

2.5 R&D

The R&D sector also uses labor as the only input.[6] The purpose of research activity is to improve productivity in a given sector and obtain a rent on the improvement. However, patents in all the lagging countries can be imperfect at protecting such rents. The imperfection of the quality of protection of intellectual property implies that at each instant of time there is a chance that the patent granted to the current monopolist becomes violable. Let σ be the instantaneous probability of such an event. In such a representation σ symbolizes both the degree of monopolistic power given to the discoverer and the quality of legal enforcement. The case of $\sigma = 0$ denotes the case when intellectual property rights are perfectly protected, i.e. there is no risk for a current state-of-the art producer that his technology becomes publicly available. The opposite limiting case of $\sigma \to \infty$ means that there is virtually no protection of intellectual property in a given country.

If a company loses its patent before a succeeding discovery occurs, its sector becomes leveled to competition and Bertrand competition drives the prices to marginal costs of production $p_{j^*t}(i) = w_{j^*t}/A_{j^*t}(i)$.

Every vertical innovation in industry i increases marginal labor output by an exogenous factor $\lambda > 1$. A successful discoverer benefits by a stream of monopolistic profits in their industry until replaced by the next discovery, or the patent becomes violable.

Successful imitation (copying) also takes the form of an increase in labor productivity by λ. Let x_{j^*t} be the difficulty parameter that adjusts the instantaneous probability of a discovery in region j^*. The ease by which the next step

[6] Note that since L is an input in research, it should be interpreted as a measure of skilled workers (capable of doing research) rather than raw labor force.

up the "quality ladder" can be taken depends on the degree a given sector in a given country lags the world technology frontier. This degree of lagging of country j^* in sector i is captured by the average technology of all the countries that are technologically advanced compared to country j^* in this sector. Thus:

$$x_{j^*t}(i) = \frac{(1-j^*)\,A_{j^*t}(i)}{\int_{j^*}^{1} f_{jt}(A_{jt}(i))dA_{jt}(i)}$$

where $f(\cdot)$ is the density function of technology in all countries, with the convention of $f > 0$ (so that countries are ordered from the most lagging to the most advanced). Such a representation of x_{j^*t} is rather complicated to use in analysis, so for tractability I work with a simplified version of this index which has similar qualitative properties. Specifically, I will utilize the average productivity level of only one country (the frontier country) as the benchmark. Such a formulation corresponds to that used in Acemoglu, Aghion and Zilibotti (2002, 2003, and 2004), where the frontier sector/country is the point of reference used there as well.

Consequently the difficulty of progress in region j^* is:

$$x_{j^*t} = \frac{A_{j^*t}}{A_{1t}}$$

where $A_{j^*t}i \equiv \int_0^{B_{j^*t}} A_{j^*t}(i)di$ is the average productivity in country j^* and A_{1t} denotes the average productivity of the frontier country[7]. The difficulty of vertical research is equal to the inverse of the distance to the technological frontier.[8]

Labor is the only input in vertical R&D and free entry is assumed. Any R&D firm that hires $n_{j^*t}(i)$ units of labor in industry i at t is successful in discovery of the next higher quality product with probability $[\phi n_{j^*t}(i)/x_{j^*t}]$ where $\phi > 0$ is the productivity parameter of vertical innovations. Denote by $V_{j^*t}(i)$ the value of a successful vertical innovation in sector i. By the no-arbitrage condition, the marginal revenue of vertical research ($[V_{j^*t}(i)\phi/x_{j^*t}]$) must be equal to the marginal costs of research w_{j^*t}, hence:

$$V_{j^*t}(i)\phi/x_{j^*t} = w_{j^*t}. \tag{13}$$

2.6 Horizontal expansion

Horizontal expansion occurs in the process of serendipitous discoveries (as in Howitt, 2000). A successful event in the process of horizontal expansion results in establishment of a new industry lab in the manufacturing sector. New monopolists enjoy a profit stream until displaced by the next discovery. Assume that the technological level of the newly established industry is randomly drawn

[7] Consequently I henceforth denote with subscript 1 all the variables related to the frontier country.

[8] Thus for the frontier country $x_{1t} = 1$.

from technological levels of existing products. Each agent has the same propensity for discovery (ψ). Moreover, the trading countries benefit from the fact that they trade with goods from various sectors, so that the volume of sectors in the globalized world is the same for all countries. The pace with which a new industry innovates is then determined by the largest country in terms of R&D capable population ($L^{\max}$).

Consequently, the rate of new product innovation in a isolated country is:

$$\dot{B}_{j^*t} = \psi L_{j^*t}, \tag{14}$$

and in the globalized world it is:

$$\dot{B}_t = \psi L_t^{\max}, \tag{15}$$

where $\psi > 0$ and $L_t^{\max}$ is the largest R&D capable population of a country engaged in globalization.

2.7 The Stock Market

There is a stock market that transfers savings of consumers to local firms engaged in R&D. It helps individuals to diversify the risk of holding stocks issued by these firms. Since, in each country, there is a continuum of industries and the expected returns to R&D activities are not firm or industry specific, each investor can completely mitigate risk by holding a perfectly diversified portfolio of stocks. Thus, the value of expected returns from holding the stocks of regional quality leaders ($V_{j^*t}(i)$) must be equal for each industry (i.e., it does not depend on i). This value equals the stream of profits discounted by the subjective rate of time - preference, rate of population growth and adjusted for the probability of losing monopolistic power. Thus:

$$V_{j^*t}(i) = \int_t^{\infty} \Pi_{j^*\tau} \exp - \left[\int_t^{\tau} \left(r + n_{j^*s}(i)\phi / x_{j^*s} + \sigma_{j^*}\right) ds \right] d\tau \tag{16}$$

Differentiating (16) with respect to time yields:

$$\frac{\Pi_{j^*t}(i) + \dot{V}_{j^*t}(i)}{V_{j^*t}(i)} - \frac{n_{j^*t}(i)\phi}{x_{j^*t}} - \sigma_{j^*} = r \tag{17}$$

For an investor in a stock, every time increment brings profits of $\Pi_{j^*t}(i)$ and appreciation of stock value of $\dot{V}_{j^*t}(i)$. In case of new discoveries or losses in IPR protection, the investor suffers a loss of $V_{j^*t}(i)$. This happens if another firm reports a success in vertical R&D (with instantaneous probability $n_{j^*}(i)\phi/x_{j^*}$) or if a given sector becomes leveled (with instantaneous probability σ_{j^*}). No arbitrage implies that this return must equal the market interest rate r.

3 The Steady-State

This section presents the solution of the model for a limiting steady-state equilibrium where all endogenous variables grow at constant rates over time. In this balanced growth equilibrium, variables that are constant over time include per-sector consumption expenditures E_{j^*}, the wage rates for labor w_{j^*}, the per–sector innovation and imitation rate n_{j^*} and the regional distance to the frontier $1/x_{j^*}$.

3.1 Horizontal Research and Labor per Sector Steady-State Conditions

This subsection solves for the horizontal expansion and labor per sector steady-state condition. Let $b_{j^*t} \equiv L_{j^*t}/B_{j^*t}$ denote the volume of labor per sector in region j^*. Thus:

$$\begin{aligned} \frac{\partial}{\partial t}\ln b_{j^*t} &= \left[\frac{\partial}{\partial t}\left(L_{j^*t}/B_{j^*t}\right)\right] / \left[L_{j^*t}/B_{j^*t}\right] \\ \frac{\partial}{\partial t}\ln b_{j^*t} &= \left(\dot{L}_{j^*t}/L_{j^*t}\right) - \left(\dot{B}_{j^*t}/B_{j^*t}\right) \end{aligned} \tag{18}$$

The rate of horizontal expansion is described for a country that remains in autarky by (14) and for a country that is engaged in globalization by (15). Thus (18) implies that for a country that is engaged in globalization b_{j^*t} converges to:

$$b_{j^*} = \frac{g_L}{\psi l_{j^*}}, \tag{19}$$

and for an isolated country:

$$b_{j^*} = \frac{g_L}{\psi}, \tag{20}$$

where l_{j^*} is the relative size of a country's compared to the largest country engaged in globalization, such that:

$$l_{j^*} \equiv \frac{L_t^{\max}}{L_{j^*t}}$$

The above presented equations mean that in all countries the value of b_{j^*} is constant over time. In other words, the number of individuals per sector is constant. In terms of individual utility from consumption (4) these results imply that for a country that engages in globalization $B_{j^*t}^{\max} = B_t$, and for a country that remains isolated $B_{j^*t}^{\max} = B_{j^*t}$.

3.2 Representative prices

This subsection introduces the notion of representative prices. A *representative price* is the expected price of a randomly selected commodity in a given region. In the frontier country, all the sectors are controlled by monopolies, so that all the prices (hence the representative price as well) are monopolistic prices. However, in the lagging countries, some sectors (fraction γ_{j^*t} of the total number of sectors) are levelled by competition and have Bertrand prices of $p_{j^*}(i) =$

$w_{j^*t}/A_{j^*t}(i)$. The values of the fractions of leveled sectors describe the market structure and can be computed as the relative instantaneous probability of losing IPR protection (σ_{j^*}) to the aggregate instantaneous probability of losing monopolistic power (by loss of IPR protection or by new discovery)[9]:

$$\gamma_{j^*} = \frac{\sigma_{j^*}}{\sigma_{j^*} + \phi n_{j^*}/x_{j^*}^C}.$$

Thus, for country j^* in steady state the representative price is:

$$p_{j^*} = w_{j^*t}/A_{j^*t}\left[\left(1-\gamma_{j^*}\right)\left(\alpha/(\alpha-1)\right)+\gamma_{j^*}\right] \tag{21}$$

Let $\Gamma_{j^*} \equiv \left[\left(1-\gamma_{j^*}\right)\left(\alpha/(\alpha-1)\right)+\gamma_{j^*}\right]$, then:

$$p_{j^*} = \Gamma_{j^*} w_{j^*t}/A_{j^*t} \tag{22}$$

3.3 Trade balance

Balance on the trade account requires that for any country j^* the values of imports and exports are equal. Hence:

$$\int_0^{B_t} p_{j^*}(i) \int_0^1 E_j \frac{\left(p_{j^*}(i)\tau_j\right)^{-\alpha}}{\int_0^1 \left(\tau_k p_k(i)\right)^{1-\alpha} dk} dj di = \int_0^{B_t} p_j(i) \int_0^1 E_{j^*} \frac{\left(p_j(i)\tau_{j^*}\right)^{-\alpha}}{\int_0^1 \left(\tau_{j^*} p_k(i)\right)^{1-\alpha} dk} dj di$$

Using the introduced notion of representative prices, the above equations can be represented as:

$$\begin{aligned}
p_{j^*}^{1-\alpha} \int_0^1 \frac{E_j/\tau_j^\alpha}{\int_0^1 \left(\tau_k p_k\right)^{1-\alpha} dk} dj &= \frac{E_{j^*}}{\tau_{j^*}} \int_0^1 \frac{p_j^{1-\alpha}}{\int_0^1 p_k^{1-\alpha} dk} dj && (23)\\
\int_0^1 \frac{E_j/\tau_{jj^*}^\alpha}{\int_0^1 \left(\tau_{jk} p_k\right)^{1-\alpha} dk} dj &= \frac{E_{j^*}}{\tau_{j^*} p_{j^*}^{1-\alpha}} && (24)\\
Q &= \frac{E_{j^*t}}{\tau_{j^*} p_{j^*t}^{1-\alpha}}. && (25)
\end{aligned}$$

Equation (25) implies that the ratio of per sector expenditures to the adjusted per capita price level is constant across the regions. Consequently, anything that could affect the world price index - particularly changes in IPR regimes of other regions (whether such changes occur in one region or in a larger group of regions) does not affect Q. Any changes abroad are neutralized by the trade account. A more detailed discussion of this feature is presented later.

Note that the constancy of Q across countries together with equation (10) translates into the following expression of instantaneous profits earned by local monopolists:

$$\Pi_{j^*} = E_{j^*}\varepsilon(\alpha)\Gamma_{j^*}^{\alpha-1}/\tau_{j^*} \tag{26}$$

[9] More formally γ_{j^*} is the limit value of market structure in country j^* described by: $\gamma_{j^*t}t = \int_0^t \left[\sigma_{j^*s}/\left(\sigma_{j^*s} + \phi n_{j^*s}/x_{j^*s}^C\right)\right] ds$

3.4 Labor Market

Every agent in each region can choose between being employed in production or in a research company. Thus, total population consists of people employed in production and vertical research. The labor market equation for each country can be represented as follows:

$$\underbrace{\int_0^{B_t} \frac{q_{j^*t}(i)}{A_{j^*t}(i)} di}_{\text{production}} + \underbrace{\int_0^{B_t} n_{j^*t}(i) di}_{\text{vertical research}} = L_{j^*t}.$$

Employment in production in country j^* is equal to: $\int_0^{B_t} q_{j^*t}(i)/A_{j^*t}(i)di$. From this, the demand equation and trade balance it follows that:

$$q_{j^*} = \frac{E_{j^*}}{\tau_{j^*} p_{j^*}} = \frac{E_{j^*} A_{j^*t}}{\Gamma_{j^*} w_{j^*t}}. \tag{27}$$

Hence for country j^* the labor market constraint is:

$$\frac{E_{j^*}}{\tau_{j^*} \Gamma_{j^*} w_{j^*}} + n_{j^*} = b_{j^*}. \tag{28}$$

3.5 The Stock Market

In the steady state equilibrium the market interest rate r by (3) equals the subjective discount factor (ρ) minus the rate of population growth (g_L). Besides, the value of expected returns from holding the stocks of a regional quality leader is constant over time (i.e. $\dot{V}_{j*} = 0$). Recall that no-arbitrage in entrepreneurial entry requires the value of a vertical discovery to be equal to the opportunity cost of research (i.e. to the wage) adjusted for the probability of achieving a given discovery (ϕ/x_{j^*t}). This is represented by equation (13) and together with (17) implies that in a steady state:

$$\frac{\Pi_{j^*}(i)}{w_{j^*} x_{j^*}} = \frac{\rho - g_L + \sigma_{j^*}}{\phi} + \frac{n_{j^*}(i)}{x_{j^*}}. \tag{29}$$

3.6 Steady-State Equilibrium

This subsection presents a detailed solution of the model for a limiting steady-state equilibrium. First, I present the solution for the frontier country and then for a representative lagging country j^*.

Since all sectors in the frontier country have monopolistic prices, solving the model for a steady-state equilibrium for the frontier country reduces to solving a system of three equations [the innovative R&D condition given by (29), profit equation (26) together with the labor market constraint (28)] in three unknowns [E_1, Π_1 and n_1]. Using Π_1 from (26) in (29) gives a system of two equations and two unknowns. In this respect, this model of trade is similar to Grossman and

Helpman (1991a), who also obtain a system where the equilibrium is determined by the profit equation and resource constraint.

Solving the profit equation [(26) and (29)] together with the labor market constraint (28) yields the following steady-state conditions for the frontier country:

$$\frac{E_1}{\tau_1}\frac{(\alpha-1)}{\alpha}+n_1 = b_1 \tag{30}$$

$$\frac{\rho-g_L}{\phi}+n_1 = \frac{E_1}{\tau_1}\frac{1}{\alpha}. \tag{31}$$

These two equations can be re-arranged to express the values of per-sector expenditures and per sector R&D intensity of the frontier country:

$$\frac{E_1}{\tau_1} = \left[b_1+\frac{\rho-g_L}{\phi}\right] \tag{32}$$

$$n_1 = \frac{b_1}{\alpha}-\frac{\rho-g_L}{\phi}\frac{\alpha-1}{\alpha}. \tag{33}$$

Before discussing the characteristics of this steady state, I briefly present the steady state in a representative lagging country. Note that the values of expenditures and research of the frontier country (E_1 and n_1) depend only on parameter values. They cannot be affected by any changes of policy in any lagging country. Hence, each lagging country takes the values of E_1 and n_1 as given.

To find the right expression for the vertical R&D intensity in j^*, recall that the difficulty parameter x_{j^*} is the inverse of the distance to the frontier $1/x_{j^*} = A_1/A_{j^*}$. In steady state, all countries have the same rate of technological progress hence $\dot{x}_{j^*} = 0$. This implies that:

$$\begin{aligned}
\partial\frac{A_1/A_{j^*}}{t}\frac{1}{A_1/A_{j^*}} &= 0\\
\frac{\dot{A}_1}{A_1} &= \frac{\dot{A}_{j^*}}{A_{j^*}}\\
n_1\ln\lambda &= n_{j^*}/x_{j^*}\ln\lambda\\
n_1 &= n_{j^*}/x_{j^*} \qquad (34)
\end{aligned}$$

Hence, in the steady state, vertical R&D intensity of a given lagging country is the frontier country's R&D intensity adjusted by the distance to the frontier.

Rearranging equation (28) together with the above expression of j^*'s vertical R&D intensity yields the lagging country's labor market condition:

$$\frac{1}{x_{j^*}} = n_1/\left[b_{j^*}-\frac{E_{j^*}}{\tau_{j^*}\Gamma_{j^*}(\sigma)w_{j^*}}\right] \tag{35}$$

The Constancy of Q implies that:

$$\frac{E_{j^*}}{\tau_{j^*}} = \frac{E_1}{\tau_1}\left(\frac{1}{x_{j^*}}\right)^{1-\alpha}\left(\frac{\alpha}{(\alpha-1)}\frac{1}{\Gamma_{j^*}(\sigma)w_{j^*}}\right)^{\alpha-1}. \tag{36}$$

Solving the imitative R&D condition (29), and substituting into (26) yields the lagging country's steady-state R&D investment condition:

$$w_S = \frac{1}{x_S^C}\frac{E_S}{\tau_S}\frac{\varepsilon(\alpha)\,\Gamma_{j^*}(\sigma)^{\alpha-1}\phi}{\rho - g_L + \sigma_{j^*} + n_N\phi}. \tag{37}$$

To close the model, note that Γ_{j^*} can be interpreted as the expected adjusted price in j^*:

$$\Gamma_{j^*}(\sigma) \equiv \left[\left(1-\frac{\sigma_{j^*}}{n_1(\alpha)\phi+\sigma_{j^*}}\right)\left(\frac{\alpha}{\alpha-1}\right)+\frac{\sigma_{j^*}}{n_1(\alpha)\phi+\sigma_{j^*}}\right], \tag{38}$$

therefore for any region j^*, $\Gamma_{j^*}(\sigma)$ can be treated as an additional parameter.

Equations (35) $\sim$ (37) can be solved for the unique equilibrium per-sector expenditures (E_{j^*}), wages (w_{j^*}) and distance to the frontier ($1/x_{j^*}$).

4 Main properties of the Steady-State equilibrium

I start the discussion of the above-described Steady-State equilibrium from the perspective of the frontier country region. The degree of IPR in any lagging country, and any foreign tariff do not appear in the frontier country's steady state conditions: (32) and (33). The volume of consumption expenditures (E_1) and vertical research (n_1) in the frontier country do not depend on any foreign IPR regime or tariff policy. Hence, the frontier's (and the world's) growth rate are unaffected by any changes in tariffs or IPR regimes in the any of the lagging countries. In summary:

Proposition 1 *In steady-state the rate of economic growth of all open economies is equal to the growth rate of the technologically most advanced economy. This rate of economic growth depends neither on any trade policies of any country (τ_{j^*}) nor on any potential changes in IPR regimes in technologically lagging countries (σ_{j^*}).*

In order to understand these results recall the equation (26). This allows for a re-interpretation of instantaneous profits: each company in a given sector sells its products abroad to foreign companies from the same sector and gets their products in exchange. These products are then sold on the local market and potential profits from this transaction are earned by local companies. In such a case, any change in the foreign price (due to change of σ_{j^*} or τ_{j^*}) is perfectly neutralized by changes in demand on markets other than j^*. In other words - any reduction in the local demand for a good on a given fraction of markets is immediately neutralized through the balanced trade account by increased demand in the remaining share of the markets. Thus, any changes of IPR policies in lagging countries, or of trade policy in any country, have no effect on expected profits from a successful discovery in the frontier country and hence are growth-neutral.

Now I restrict myself to study the effects of changes of IPR and tariffs on a given lagging country. To study these effects I concentrate on the equations (35) $\sim$ (37). Plugging (37) for wages into (35) and solving for per sector expenditures gives the unique solution for the distance to the frontier of a representative lagging country j^*:

$$\frac{1}{x_{j^*}} = [n_1 + \delta(\sigma_{j^*})] \left[(1-h)\, b_{j^*}\right]^{-1} \tag{39}$$

where:

$$\delta(\sigma_{j^*}) \equiv \frac{\rho - g_L + \sigma_{j^*} + n_1\phi}{\varepsilon(\alpha)\, \Gamma_{j^*}(\sigma)^{\alpha}\phi}.$$

Note that when $\sigma_{j^*} = 0$ (i.e. when the intellectual property rights in a given lagging country are perfect) then $1/x_{j^*} = L_1/L_{j^*}$. Thus, when intellectual property is perfect, relative productivity of a given region is proportional to its size measured in R&D capable labor force. However, if patents are imperfect, then distance to the frontier increases with reductions in the quality of IPR protection. ($\partial\Gamma_{j^*}/\partial\sigma_{j^*} < 0$ hence $\partial\left(1/x_{j^*}\right)/\partial\sigma_{j^*} > 0$). Consequently, a discrete improvement of a country's IPR regime results in conditional convergence to a new position that is closer to the technological frontier. This is in contrast with the recent theories on IPR and development (Helpman 1993, Grossman and Lai, 2004). Taking into account the empirical finding about the costliness of the technological transfer changes the results - IPR are useful also for the lagging countries. Figure one presents an illustration of the dependence of distance to the frontier as a function of quality of IPR and size of given economy (measured in R&D capable workers).

The distance to the frontier of the given following economy ($1/x_{j^*}$) is presented on the vertical axis - higher values of $1/x_{j^*}$ correspond to greater distance to the frontier. The horizontal axes represent the relative size of given economy (L_1/L_{j^*}) and the inverse of the quality of intellectual property protection (σ_{j^*}). The function presented in the figure increases in σ_{j^*} and decreases in L_1/L_{j^*}. Thus, larger economies (in terms of R&D capable population) tend to be located closer to the technological frontier. Weaker protection of intellectual property (higher σ_{j^*}) increases the distance to the technological leader.

Similarly, as in the frontier country, trade restrictions have no effect on conditional convergence of lagging countries. The underlying mechanism for this is the same as in the frontier country - any changes in tariffs result only in changes in trade volumes but not in expected rewards from monopolistic profits. A potential increase in tariffs in some regions causes a decrease in exports to these regions but the potential losses from this export slowdown are perfectly neutralized by increased exports to other markets. These results tend to suggest

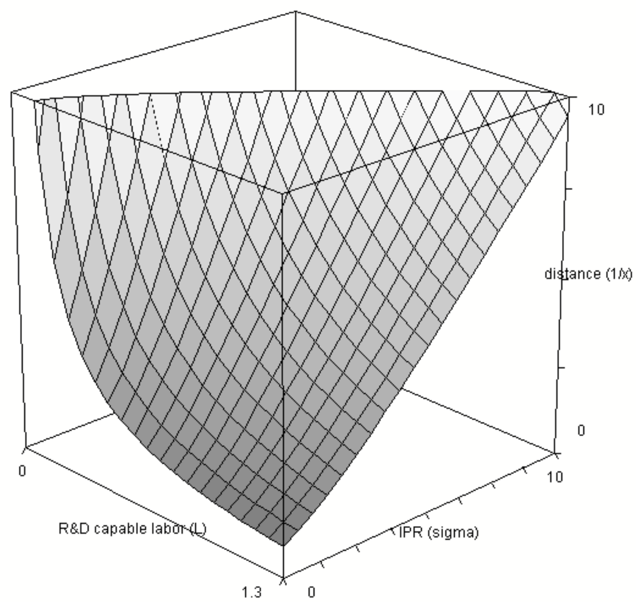

Figure 1: *Distance to the frontier as a function of IPR quality and volume of R&D capable labor.*

that, for a given lagging country, an improvement in the IPR regime seems to be a better solution than pursuing tariff changes. The conclusions presented above are summarized in the following proposition:

Proposition 2 *In a steady-state, a country's relative per capita income depends positively on its degree of protection of intellectual property rights (σ_{j^*}) and its size in terms of R&D capable population (L_{j^*}). Import tariffs (τ_{j^*}) are neutral in their effect on a country's relative per capita income.*

4.1 Benefits of engagement.

The model allows me to address the question of potential benefits of engaging in globalization. I consider engagement as accessing world trade and opening to the international flow of ideas. The previous subsection analyzed the case of a given lagging country participating in both international trade as well as in international ideas transfer. This sections studies the case when a given lagging country does not open at all (remains in autarky).

The case when a given country opens to the international flow of ideas only has been developed by Howitt (2000) and further analyzed by Klenow and Rodríguez (2005). They found that engagement in the world flow of ideas significantly improves the economic performance of a single country, compared to the case of autarky. This subsection further contributes by analyzing the cases when trade openness is also possible.

A country becomes closed to trade (e.g. because $\tau_{j^*} = +\infty$ or because trade is excluded exogenously by geographical distance or some non-tariff barriers) and has no access to international flow of ideas. This implies that output is sold on the local market only.[10] Such a specification allows us to solve the model's steady-state equations just for a single country. As shown in the appendix the final vertical R&D intensity and growth rate is constant and depends positively on the quality of IPR protection.

A surprising finding is that autarky can lead to higher growth rates than full openness. Under openness a country grows at a rate that is proportional to the frontier's country growth rate n_1. Under autarky a country's growth depends on only its own R&D. However, it may grow faster because fewer sectors will be opened. Specifically, if this country can impose strict IPR protection it can actually achieve a higher rate of growth than it would under full participation in global markets. In summary:

Proposition 3 *If a given closed economy can impose a sufficiently high degree of protection of intellectual property, and if the degree of competition in its local market is lower than in the international markets, then this economy can achieve higher rates of economic growth than if it were open.*

Figure two presents this case graphically. The horizontal line (INT) represents the frontier's R&D intensity - thus the growth rate of the globalized world.

[10] In such setting local competition constraints the monopolistic price. Hence for i being monopolistic $p_{j^*t}(i) = \lambda$

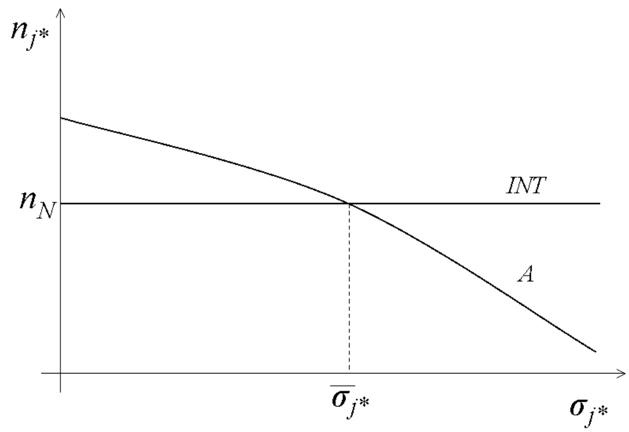

Figure 2: *Vertical R&D intensity of a closed - economy j^**

This rate does not depend on the level of protection of intellectual property in a single economy, thus INT does not change in σ_{j^*}. The line A symbolizes vertical R&D intensity in j^* as a function of IPR quality in this country. As shown in the appendix this line is downward - sloping in σ_{j^*}. All IPR levels higher than $\bar{\sigma}_{j^*}$ result in a higher growth rate than the frontier's. Note that the possibility of higher growth in a closed economy occurs as long as $\lambda > \alpha/(\alpha-1)$, i.e. when international competition is more intense than local (limited by the size of discovery λ). If this does not hold, local competition is as intense as international, closed economies are not able to generate higher growth than the globalized world. This case corresponds to the dashed line A' in figure two. Country j^* cannot obtain higher intensity of vertical R&D than the open economies. Moreover, any weakening of IPR protection in j^* results in lower intensity of research and leads to slower growth and divergence.

4.2 Income Structure

To close this section I examine the potential consequences of IPR improvements on the income composition of a given lagging country. A commonly raised argument against stronger intellectual property protection is that it benefits only “capitalists” whose incomes come mostly as dividends from invested capital. According to such reasoning, workers whose incomes consist mostly of wages, do not benefit from these changes as much as "capitalists".

I study this claim by analyzing the effect of changes of σ_{j^*} on the composition of individual income. There are two main components of individual income: wages earned in production/research and dividends paid by monopolistic companies that produce consumption goods. Using (10) and (37) the ratio of wages and monopolistic profits is:

$$\frac{w_{j^*}}{\Pi_{j^*}} = \frac{\rho - g_L + \sigma_{j^*} + n_1\phi + \varepsilon(\alpha)}{\varepsilon(\alpha)^2 \Gamma_{j^*}(\sigma)\phi} n_1,$$

which can be re-expressed as:

$$\frac{w_{j^*}}{\Pi_{j^*}} = \frac{(\sigma_{j^*} + \varkappa_1)n_1}{\varkappa_2 \left[\left(1 - \frac{\sigma_{j^*}}{n_1\phi + \sigma_{j^*}}\right)\varkappa_3 + \frac{\sigma_{j^*}}{n_1\phi + \sigma_{j^*}}\right]},$$

where:

$$\begin{aligned}
\varkappa_1 &\equiv \rho - g_L + n_1\phi + \varepsilon(\alpha) \\
\varkappa_2 &\equiv \varepsilon(\alpha)^2 \phi \\
\varkappa_3 &\equiv \left(\frac{\alpha}{\alpha - 1}\right).
\end{aligned}$$

Rearranging yields:

$$\frac{w_{j^*}}{\Pi_{j^*}} = \frac{n_1(\varkappa_1 + \sigma_{j^*})(\phi n_1 + \sigma_{j^*})}{\varkappa_2(\varkappa_3\phi n_1 + \sigma_{j^*})}.$$

Thus:

$$\frac{\partial [w_{j^*}/\Pi_{j^*}]}{\partial \sigma_{j^*}} = \frac{n_1\left(\varkappa_3\phi n_1(\varkappa_1 + \phi n_1 + 2\sigma_{j^*}) - \phi n_1\varkappa_1 + \sigma_{j^*}^2\right)}{\varkappa_2(\varkappa_3\phi n_1 + \sigma_{j^*})^2},$$

since:

$$\begin{aligned}
\varkappa_3\phi n_1(\varkappa_1 + \phi n_1 + 2\sigma_S) - \phi n_1\varkappa_1 &> 0 \\
\varkappa_3(\varkappa_1 + \phi n_1 + 2\sigma_{j^*}) - \varkappa_1 &> 0 \\
\frac{\partial [w_{j^*}/\Pi_{j^*}]}{\partial \sigma_{j^*}} &> 0
\end{aligned}$$

Hence the derivative of the above expression with respect to σ_{j^*} is positive. Thus an improvement of the quality of IPR protection reduces the wage/profit ratio. Weaker IPR implies that a larger share of income comes from wages paid to labor, whereas stronger IPR translates into higher significance of profits from successful R&D investments. If a country has an unequal distribution of equities, an improvement in IPR could indeed lead to a significant distortion away from labor, and increase inequality.

5 The Empirical Example

A simple look at some readily available cross-country data is consistent with the findings presented above. I check the theoretical prediction about the significance of IPR and insignificance of tariffs on the distance to the frontier.

According to propositions two and three, weaker IPR should increase the distance to the frontier of given country irrespective of its openness. To do this I need data on Intellectual Property Rights quality (IPR_{jt}) across the world. There are two issues that need to be addressed when specifying the quality of IPR: the quality of law and the level of its enforcement. I refer to the IPR quality index introduced by Ostergard (2000). This index is a multiplier of the degree to which intellectual property is literally protected with the quality of enforcement of given law. Higher values of the index correspond to higher quality of IPR in a given country. The values of the index range from five (the best quality of IPR protection) to one (the worst quality of IPR protection). The second observable is the distance to the frontier ($DIST_{jt}$), taken from Penn World Table on real GDP per capita relative to the United States. My sample consists of 67 countries[11], both OECD and non-OECD economies.

Following the theoretical predictions of Howitt (2000) and signalled by the empirical studies of Lichtenberg (1993), I decide to control for the effects of investments on economic distance. I include the rate of investments as another control variable in the regression. I take the data from Penn World Table on the share of investments in GDP. Other controls I include in my sample are the degree of openness, country size and the set of geographical characteristics.

The estimates of the linear coefficients are presented in Table 1. These estimates are consistent with the theoretical predictions. The IPR coefficient is always negative and highly significant. Adding the time dummy or various controls does not affect the result.

Table one (dependent variable $DIST_{jt}$):

IPR_{jt}	17.274^{***} (1.306)	12.991^{***} (1.237)	12.501^{***} (1.203)	13.025^{***} (1.239)
Investments		1.440^{***} (0.173)	1.563^{***} (0.180)	1.433^{***} (0.171)
Openness		-0.008 (0.043)		
Africa			-3.743 (4.984)	
East Asia			-15.617^{***} (4.125)	
Time dummy				0.610 (1.545)
R^2	0.467	0.607	0.635	0.607

An additional exercise is to check the role of openness in the relationship between IPR and distance to frontier. To perform this exercise, the first step is

[11] Argentina, Australia, Austria, Bangladesh, Barbados, Belgium, Bolivia, Brazil, Canada, Chile, China, Colombia, Congo (Zaire), Costa Rica, Denmark, Dominican Rep., Ecuador, Egypt, El Salvador, Finland, France, Germany, Ghana, Greece, Guatemala, Haiti, Honduras, Hungary, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, South Africa, Spain, Sweden, Switzerland, Syria, Thailand, Trinidad & Tobago, Tunisia, Turkey, UK, Uruguay, USA Venezuela.

to specify the subsets of open and closed economies. To do so it is not enough to look at the tariff rates or at the share of trade in GDP. In fact tariffs are just a nominal control variable and do not reflect many non - tariff barriers as well as whether a given economy is oriented to exchange with the globalized world or not. The share of trade in GDP is a highly endogenous variable and cannot be used as a credible proxy of openness. In order to determine the degree of openness of developing economies I take the index of openness introduced by Sachs and Warner (1995) where the "openness" of a given country depends on average level of tariff and non-tariff barriers, black market premia, central control of major exports, or whether a given country is classified as "socialist".

Having defined the sub-samples that contain open and closed economies I perform the regressions with distance to frontier (real GDP per capita relative to the United States) as the dependant variable. The estimated values of parameters for the open economies are presented in table two, the results for closed economies are presented in table three. Again, intellectual property rights is highly significant for the distance to frontier of given country.

Table two, open economies (83 observations, dependant variable $DIST_{it}$):

IPR_{jt}	17.535*** (1.894)	14.562*** (1.847)	14.457*** (1.855)	14.523*** (1.854)
Investments		1.198*** (0.276)	1.218*** (0.278)	1.180*** (0.278)
Openness			−0.054 (0.066)	
Time dummy				−2.859 (4.122)
R^2	0.513	0.606	0.609	0.608

Table three, closed economies (51 observations, dependant variable $DIST_{it}$):

IPR_{jt}	4.169*** (1.378)	3.979*** (1.346)	3.790*** (1.391)
Investments		0.514* (0.269)	0.491* (0.273)
Time dummy			−1.691 (2.791)
R^2	0.157	0.216	0.222

These correlations are not a test of the model, but it is encouraging that these are consistent with the theoretical predictions. Better protection of intellectual property tends to reduce the distance to the frontier. A more in depth empirical analysis of this issue is a worthwhile subject of future research.

6 Conclusions

A central finding here is that the long run growth rate is unaffected by either trade agreements or potential changes in IPR regimes in technologically lagging countries. This conclusion comes from the analysis of a standard multi-country model of trade and economic growth without scale effects. The conclusion is consistent with the empirical observations of no effect of factor input growth or increasing trade volumes on apparent long run economic growth rates in industrialized countries.

The second message that comes from this paper is that because diffusion of technologies is not costless, differences in knowledge adoption intensities may explain a significant portion of income differences across countries. There are two main components that affect the cross - country differences in copying activities: Firstly, the degree of intellectual property rights protection significantly affects the long run relative productivity of a given country. Since the degree to which intellectual property is protected positively affects incentives to imitate, an improvement of IPR regime results in conditional convergence towards the technological frontier and to a new steady-state equilibrium. Secondly, the volume of skilled labor determines the relative position of a lagging region. Because of positive externalities, larger countries offer products that are more desired by consumers. This translates into higher expected profits from successful research and higher R&D. These two conclusions fit well the commonly known empirical observations on conditional convergence (see Barro, 2001). The results of two simple empirical regressions presented in section five additionally support these findings.

The third observation is about the possible positive effects of no openness at all (in terms of trade and knowledge flows) on growth of a country. This is because openness tends to utilize a country's resources in full R&D engagement in all the sectors that are subject to trade. This has the effect of diluting R&D effort and lowering aggregate growth. By contrast under autarky, a potentially higher growth rate may be generated since there is no dilution.

The last conclusion that needs to be highlighted regards the potential drawbacks of IPR improvement. My model shows that better protection of intellectual property causes a shift in the distribution of individual income. A larger share of individual income comes from dividends paid by monopolistic firms. When there exists an unequal distribution of assets in a given society, this could lead to a significant distortion away from labour. Increasing inequality could trigger some undesired phenomena such as corruption and rent - seeking, that could even halt the development of a given region.

I finish this section with an indication of some points in the analysis that will be extended and improved in future research. I assumed throughout that each country was too small to affect world prices. This assumption will be relaxed in future studies. Doing so would allow one to check what happens if a single market matters for pricing decisions of firms or if a firm has enough market power to affect the prices in its sector. Another interesting task would be to focus more on the aspect of local (domestic) competition. Clearly the IPR parameter σ_{j^*} captures to some extent the degree of domestic competition. Nevertheless, in my study international competition was the major force driving the monopolistic decision. One could go a step further and distinguish between IPR and local competition policy. Finally future research could focus on the identification of the other factors that affect international knowledge spillovers Joint ventures, capital flows, migration of key personnel and cultural/geographical proximity may all play important roles.

References

[1] Acemoglu, D., Aghion, P., Zilibotti, F., 2002. Vertical Integration and Distance to Frontier. NBER Working Paper no. 9191.

[2] Acemoglu, D., Aghion, P., Zilibotti, F., 2003. Distance to Frontier, Selection, and Economic Growth. mimeo, http://post.economics.harvard.edu/faculty/aghion

[3] Aghion, P., Howitt, P., 1992. A Model of Growth through Creative Destruction. Econometrica 60, 323-352.

[4] Armington, P., 1969. A Theory of Demand for Products Distinguished by Place and Production. IMF Staff Papers 16, 159-178.

[5] Balland, J.-M., Francois, P., 1996. Innovation, Monopolies and the Poverty Trap. Journal of Development Economics 49, 151-78.

[6] Barro, R., 2001. Determinants of Economic Growth. MIT Press, Cambridge, Massachusetts.

[7] Barro, R., Sala-I-Martin, X., 1995. Economic Growth. McGraw-Hill, New York.

[8] Barro, R., Sala-I-Martin, X., 1997. Technological Diffusion, Convergence and Growth. Journal of Economic Growth 2, 1-26.

[9] Benhabib, J., Spiegel, M., 2002. Human Capital and Technology Diffusion. FRSBF Working Paper no. 2003-02.

[10] Coe, D., Helpman, E., 1995. International R&D Spillovers. European Economic Review 39, 859-887.

[11] Connolly, M., Valderrama, D., 2005. Implications of Intellectual Property Rights for Dynamic Gains from Trade. American Economic Review Papers and Proceedings 95, 318-322.

[12] Dinopoulos, E., Segerstrom, P., 1999. A Schumpeterian Model of Protection and Relative Wages. American Economic Review 89, 450-472.

[13] Dinopoulos, E., Segerstrom, P., 2005. A Theory of North-South Trade and Globalization. mimeo, http:/web.hhs.se/personal/Segerstrom

[14] Eaton, J., Kortum,S., 1999. International Technology Diffusion: Theory and Measurement. International Economic Review 40, 537-70.

[15] Frankel, J., Romer, D., 1999. Does Trade Cause Growth? American Economic Review 89, 379-399.

[16] Gancia, G., 2003. Globalization, Divergence and Stagnation. Stockholm University, Institute for International Economic Studies, Seminar Paper No. 720.

[17] Grossman, G., Helpman, E., 1991a. Quality Ladders in the Theory of Growth. Review of Economic Studies 58, 43-61.

[18] Grossman, G., Helpman, E., 1991b. Trade, Knowledge Spillovers and Growth. European Economic Review 35, 517-526.

[19] Grossman, G., Lai, E., 2002. International Protection of Intellectual Property. NBER Working Paper No. 8704.

[20] Helpman, E., 1993. Innovation, Imitation, and Intellectual Property Rights. Econometrica 61, 1247-80.

[21] Heston, A., Summers, R., Aten, B., 2002. Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP).

[22] Howitt, P., 1999. Steady Endogenous Growth with Population and R&D Inputs Growing. Journal of Political Economy 107, 715-730.

[23] Howitt, P., 2000. Endogenous Growth and Cross-Country Income Differences. American Economic Review 90, 829-846.

[24] Jones, Ch., 1995. R&D-Based Models of Economic Growth. Journal of Political Economy 103, 759-784.

[25] Keely, L., 2000. Using patents in growth models. Wisconsin Madison - Social Systems, Working papers 30.

[26] Klenow, P., Rodríguez, A., 2005, Externalities and Growth, in: Aghion, P., Durlauf, S., (Eds.), Handbook of Economic Growth, Vol. 1, Elsevier, pp. 817-861.

[27] Kortum, S., 1993. Equilibrium R&D and the Patent-R&D Ration: US Evidence. American Economic Review 83, 450-457

[28] Kortum, S., 1997. Research, Patenting and Technological Change. Econometrica 65, 1389-1419.

[29] Krugman, P., Obstfeld, M., 1994. International Economics: Theory and Policy. Addison Wesley.

[30] Lichtenberg, F., 1993. R&D Investment and International Productivity Differences. NBER Working Paper no. 4161.

[31] Mansfield, E., Schwartz M., Wagner, S., 1981. Imitation Costs and Patents: An Empirical Study. The Economic Journal 91, 907-18.

[32] Ostergard, R., 2000. The Measurement of Intellectual Property Rights Protection. Journal of International Business Studies 31, 349-360.

[33] Peretto, P., Smulders, S., 2002. Technological Distance, Growth and Scale Effects. Economic Journal 112, 603-624.

[34] Sachs, J., Warner, A., 1995. Economic Reform and the Process of Global Integration. Brookings Papers on Economic Activity, Issue 1, 1-118.

[35] Taylor, M., 1993. TRIPS, Trade, and Technology Transfer. Canadian Journal of Economics 26, 625-37.

[36] Taylor, M., 1994. TRIPs, Trade, and Growth, International Economic Review 35, 361-81.

[37] Segerstrom, P., Anant, T. C. A., Dinopoulos, E., 1990. A Schumpeterian Model of the Product Life Cycle. American Economic Review 80, 1077-91.

[38] Segerstrom, P., 1998. Endogenous Growth Without Scale Effects. American Economic Review 88,1290-1310.

[39] Young, A., 1998. Growth Without Scale Effects. Journal of Political Economy 106, 41-63.

Appendix

IPR and growth in a closed economy:

When a monopolist in j^* is constraint by the local competition only, it sets the price equal to the marginal cost of the previous monopolist in given sector: $\lambda w_{j^*t}/A_{j^*t}$. Thus, the scaling parameter for the price level in given country j^* becomes:

$$\Gamma_{j^*} \equiv \left[\left(1 - \frac{\sigma_{j^*}}{\sigma_{j^*} + n_{j^*}\phi} \right) \lambda + \frac{\sigma_{j^*}}{\sigma_{j^*} + n_{j^*}\phi} \right]$$

and the expected price equals to:

$$p_{j^*} = \Gamma_{j^*} w_{j^*t} / A_{j^*t} \tag{40}$$

This, together with (28) gives the labor market equation:

$$\frac{E_{j^*}}{\Gamma_{j^*}} + n_{j^*} = (1-h)\, b_{j^*} \tag{41}$$

where:

$$\begin{aligned} b &= g_L \left(\frac{\psi}{\phi} \right)^{\frac{\psi}{\psi-1}} \\ h &= \left(\frac{\phi}{\psi} \right)^{\frac{1}{\psi-1}} \end{aligned}$$

The monopolistic profits earned by a monopolist in j^* become:

$$\Pi_{j^*} = (1 - 1/\lambda)\, E_{j^*} \tag{42}$$

The profit condition is derived by plugging (42) into (29):

$$(1 - 1/\lambda)\, E_{j^*} = \frac{\rho - g_L + \sigma_{j^*}}{\phi} + n_{j^*} \tag{43}$$

The above - presented labor market equation and profit condition can be rewritten as the quadratic equation of n_{j^*}:

$$\chi_0 n_{j^*}^2 + \chi_1 n_{j^*} = \chi_2 \tag{44}$$

where:

$$\begin{aligned} \chi_0 &\equiv \phi\lambda^2 / (\lambda - 1) \\ \chi_1 (\sigma_{j^*}) &\equiv \frac{\lambda}{\lambda - 1} \left[\sigma_{j^*} + (\rho + g_L)\, \sigma_{j^*} / \phi\right] + \sigma_{j^*} - (1 - h)\, b \\ \chi_2 (\sigma_{j^*}) &\equiv \sigma_{j^*} \left[(\rho - g_L + \sigma_{j^*})\, (\lambda - 1) / (\phi\lambda) - (1 - h)\, b\right] \end{aligned}$$

so that n_{j^*} is the positive square - root of (44) given by:

$$n_{j^*} (\sigma_{j^*}) = \frac{\sqrt{\chi_1^2 (\sigma_{j^*}) - 4\chi_0\chi_2 (\sigma_{j^*})} - \chi_1 (\sigma_{j^*})}{2\chi_0}$$

The derivative of the above expression with respect to σ_{j^*} is:

$$n_{j^*}' (\sigma_{j^*}) = -\frac{\chi_1' (\sigma_{j^*}) \left[\sqrt{\chi_1^2 (\sigma_{j^*}) - 4\chi_0\chi_2 (\sigma_{j^*})} - \chi_1 (\sigma_{j^*})\right] + 2\chi_0\chi_2' (\sigma_{j^*})}{2\chi_0 \sqrt{\chi_1^2 (\sigma_{j^*}) - 4\chi_0\chi_2 (\sigma_{j^*})}}$$

Since $\chi_1' (\sigma_{j^*}) > 0, \chi_2' (\sigma_{j^*}) > 0$ it follows that[12] $n_{j^*}' (\sigma_{j^*}) < 0$.

[12] Particularly, expanding the numerator yields to a conlcusion that $n_{j^*}' (\sigma_{j^*})$ is negative as long as: $\sigma_{j^*} \left(4\lambda^3 - 9\lambda^2 + 6\lambda - 1\right) + \lambda[(1-h)b\phi(\lambda-1)^2 + (\rho - g_L)(2\lambda^2 - 3\lambda + 1)]$
For positive σ_{j^*} this holds since $\lambda > 1$.